

How does orange peel help with battery recycling?

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Scientists from [Nanyang Technological University, Singapore](#) (NTU Singapore) have developed a novel method of using fruit peel waste to extract and re-use precious metals from spent lithium-ion batteries in order to create new batteries — an approach that will help bring down the 3 billion tonnes of food waste and 50 million tonnes of e-waste that are generated every year. Their method has been described in the journal *Environmental Science & Technology*.

Spent batteries are conventionally treated with extreme heat (over 500°C) to smelt valuable metals, which emits hazardous toxic gases. Alternative approaches that use strong acid solutions or weaker acid solutions with hydrogen peroxide to extract the metals are being explored, but either produce secondary pollutants, which pose health and safety risks, or rely on hydrogen peroxide, which is hazardous and unstable.

With industrial approaches to recycling battery waste generating harmful pollutants, hydrometallurgy — using water as a solvent for extraction — is being explored as a possible alternative. This process involves first shredding and crushing used batteries to form a crushed material called black mass. Researchers then extract valuable metals from the black mass by dissolving it in a mix of strong acids or weak acids plus other chemicals like hydrogen peroxide under heat, before letting the metals precipitate.

While relatively more eco-friendly than conventional methods, the use of such strong chemicals on an industrial scale could generate a substantial amount of secondary pollutants, posing significant safety and health risks. And it turns out that the combination of orange peel that has been oven-dried and ground into powder and citric acid, a weak organic acid found in citrus fruits, can achieve the same goal.

Using the latter method in lab experiments, the NTU team found that they could successfully extract around 90% of cobalt, lithium, nickel and manganese from spent lithium-ion batteries — a comparable efficacy to the approach using hydrogen peroxide. As explained by NTU's Assistant Professor Dalton

Tay, “The key lies in the cellulose found in orange peel, which is converted into sugars under heat during the extraction process.

“These sugars enhance the recovery of metals from battery waste. Naturally occurring antioxidants found in orange peel, such as flavonoids and phenolic acids, could have contributed to this enhancement as well.”

Solid residues generated from this process were found to be non-toxic, suggesting that the new method is environmentally sound. The team were also able to use the recovered materials to assemble new lithium-ion batteries, which showed a similar charge capacity to commercial ones.

This suggests that this new technology is practically feasible for recycling spent lithium-ion batteries in the industrial sense. The team is now looking to further improve the performance of their batteries generated from treated battery waste, as well as to optimise the conditions to scale up production and explore the possibility of removing the use of acids in the process.

“This waste-to-resource approach could also potentially be extended to other types of cellulose-rich fruit and vegetable waste, as well as lithium-ion battery types such as lithium iron phosphate and lithium nickel manganese cobalt oxide,” said NTU’s Professor Madhavi Srinivasan. “This would help to make great strides towards the new circular economy of e-waste and power our lives in a greener and more sustainable manner.”

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